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(TOBS) Tethered, ocean bottom seismometer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The Hawaii Institute of Geophysics ~~(HIG)~~ has developed two major exploration ocean bottom seismometer ~~(OBS)~~ systems. One operates as a free vertical pop-up ocean bottom seismometer ~~(POBS)~~ and the other is a larger, tethered, ocean bottom seismometer. ~~(TOBS)~~ In both instruments it is necessary to maintain proper orientation of the geophones while the instrument is operating. This proper orientation is maintained by gimballing the geophones.

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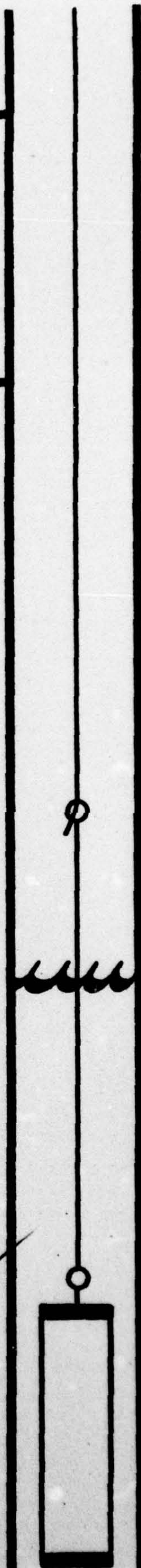
OCEAN BOTTOM SEISMOMETER GIMBAL SYSTEMS



The Hawaii Institute of Geophysics (HIG) has developed two major exploration ocean bottom seismometer (OBS) systems. One operates as a free vertical pop-up ocean bottom seismometer (POBS) and the other is a larger, tethered, ocean bottom seismometer (TOBS). In both instruments it is necessary to maintain proper orientation of the geophones while the instrument is operating. This proper orientation is maintained by gimballing the geophones.

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Slip Ring and Brush Assemblies

Both gimbal systems use a printed circuit (PC), slip ring, and 14-kt-gold brush assembly developed at HIG. The slip rings, brush plate, and a PC board (Figure 1), are etched and plated using the following materials and techniques:

- Base Material--G-10 epoxy glass, .062-inch (.157 cm) nominal thickness, 1-oz copper laminate, single side.
- Nickel Plate--.0001-inch (2.54×10^{-4} cm) nominal electroplate over copper, (Techni-Nickel WS by Technic, Inc.).
- Gold Plate--.000046-inch (1.168×10^{-4} cm) nominal electroplate over nickel. (Orosene PC by Technic, Inc.).

After manufacture the PC cards are machined to fit the gimbal system (Figure 2).

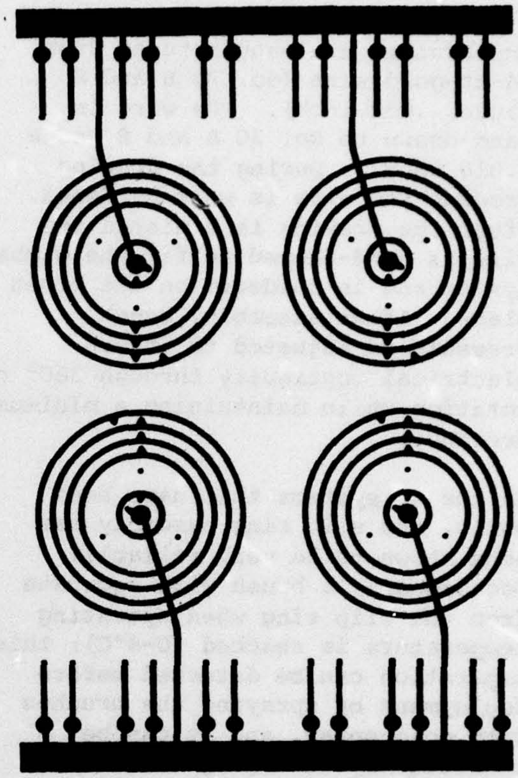

Figure 1.

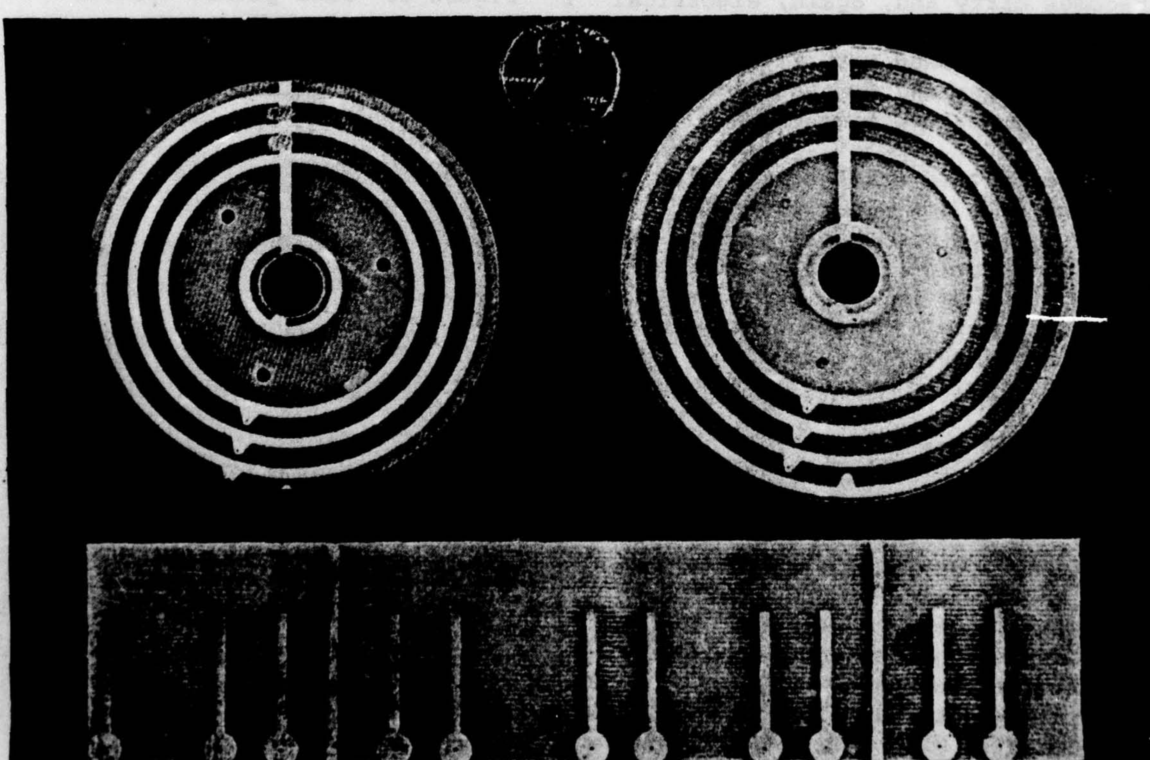

Figure 2.

The brushes are manufactured from 14-kt-gold wire (No. 20 B and S gauge, .032 inch). The wire is hand-drawn to No. 30 B and S gauge (.010 inch). During the drawing process the wire is work-hardened. After the drawing is finished the wire is hand-shaped to fit the gimbal system and is soldered on the brush plate. After assembly, brush pressure is adjusted to insure electrical continuity through 360° of rotation while maintaining a minimum pressure.

In the 40 systems that have been built, the slip ring assembly has been shown to be very reliable. Occasionally a brush will separate from the slip ring when operating temperature is reached (0-4°C); this separation can be detected before deployment by spraying the brushes with cold spray, and it can be corrected by reshaping the brush. The slip ring assembly sometimes becomes dirty and, again, electrical continuity may be lost. The slip rings are cleaned with a common pencil eraser and sprayed lightly with a no-residue cleaner.

The use of gold enables reliable contact with low wiper pressure. Consequently, mechanical resistance to gimbal motion is minimized but the combination of bearing friction and brush pressure is great enough to lock the gimbal for seismic displacement.

POBS Gimbal Systems

The POBS gimbal system (Figures 3 and 4) has two components. The geophones used, one vertical and one horizontal, are the Geospace HS-1-K with an impedance of 900 Ω and a natural frequency of 4.5 Hz. For our purpose, the geophones are slightly modified by Geospace Corp. by removing the threaded bottom stud and replacing it with a flat-head machine screw. They are locked in the gimbal cylinder with two set screws.

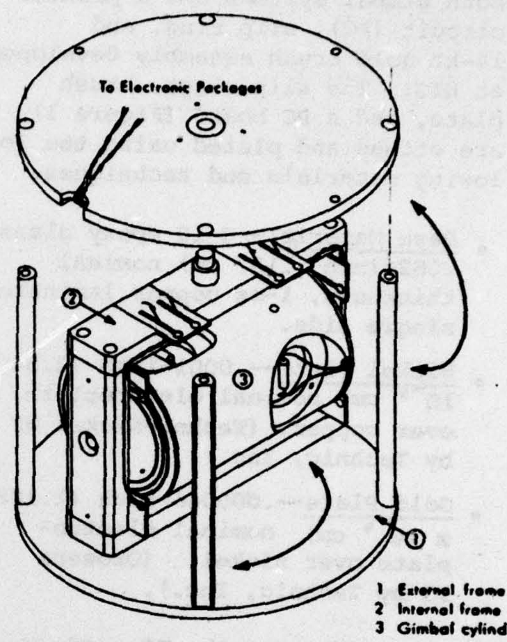

Figure 3. POBS gimbal system, exploded view.

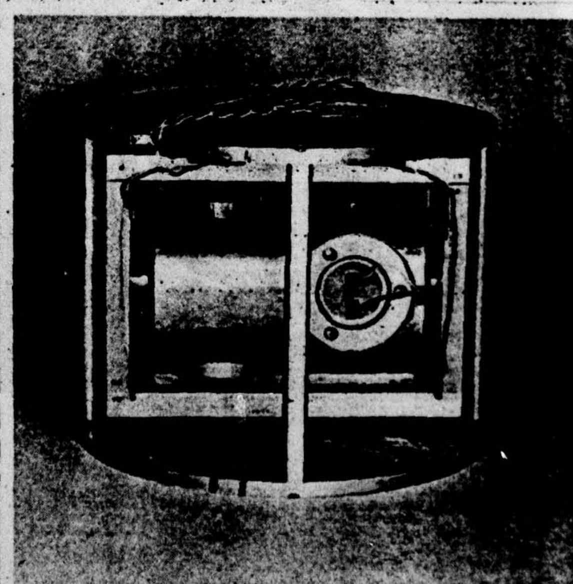

Figure 4. POBS gimbal system.

The gimbal system, designed to fit a 14-cm inside-diameter pressure case, is 11.75 cm long and weighs 2 kg in air. It is divided into three subassemblies: the gimbal cylinder, an internal frame, and an external frame. The subassemblies give the gimbal two degrees of freedom. A strip of lead is mounted on the bottom of the gimbal cylinder to insure proper leveling. Gravity acting on the gimbal continuously readjusts the gimbal level as the instrument settles in the abyssal ooze.

Care must be taken when wiper pressure is adjusted. The mass of the gimbal cylinder and internal frame (Figures 5 and 6) is small enough that wiper friction can prevent their leveling in the gimbal.

The magnitude of the contact resistance is of little consequence because the currents flowing through the slip ring assemblies are very small. The damping resistor (1.8 kΩ) is soldered directly to the geophone terminals; the input resistance of the signal package (greater than 2 MΩ) limits slip ring current to nanoamperes.

TOBS Gimbal Subsystem

The TOBS gimbals (Figures 7 and 8) use three geophones. The gimbal frame allows the geophones to rotate 360° about the long axis of a 19-cm ID pressure case. However, two geophones (a vertical and horizontal) have their own set of bearings, allowing them to rotate up to 45° to compensate for elevation of either end of the pressure case. The second horizontal geophone, perpendicular to the long axis of the pressure case, is capable of operation with 360° of rotation around its axis. Lead weights are attached to each geophone

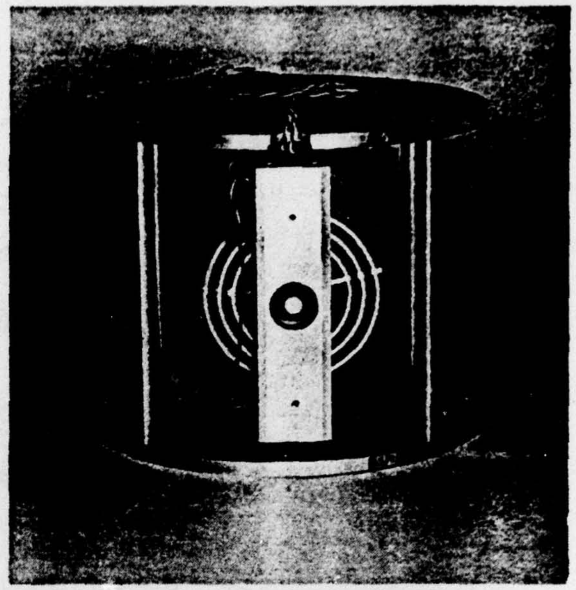

Figure 5. POBS gimbal cylinder slip ring assembly.

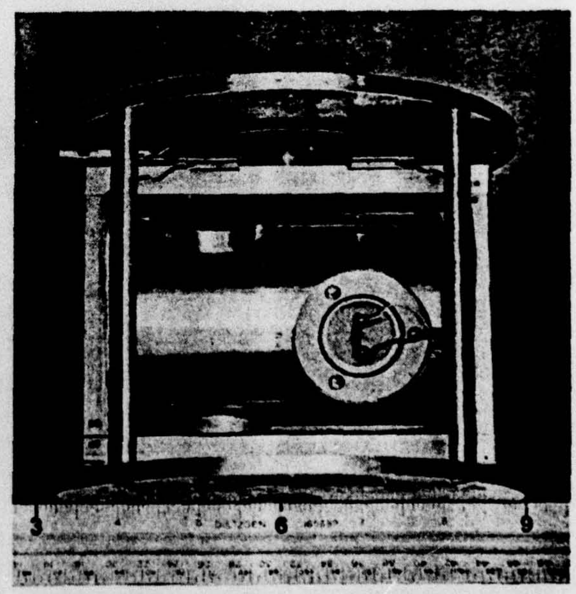

Figure 6. POBS gimbal frame slip ring assembly.

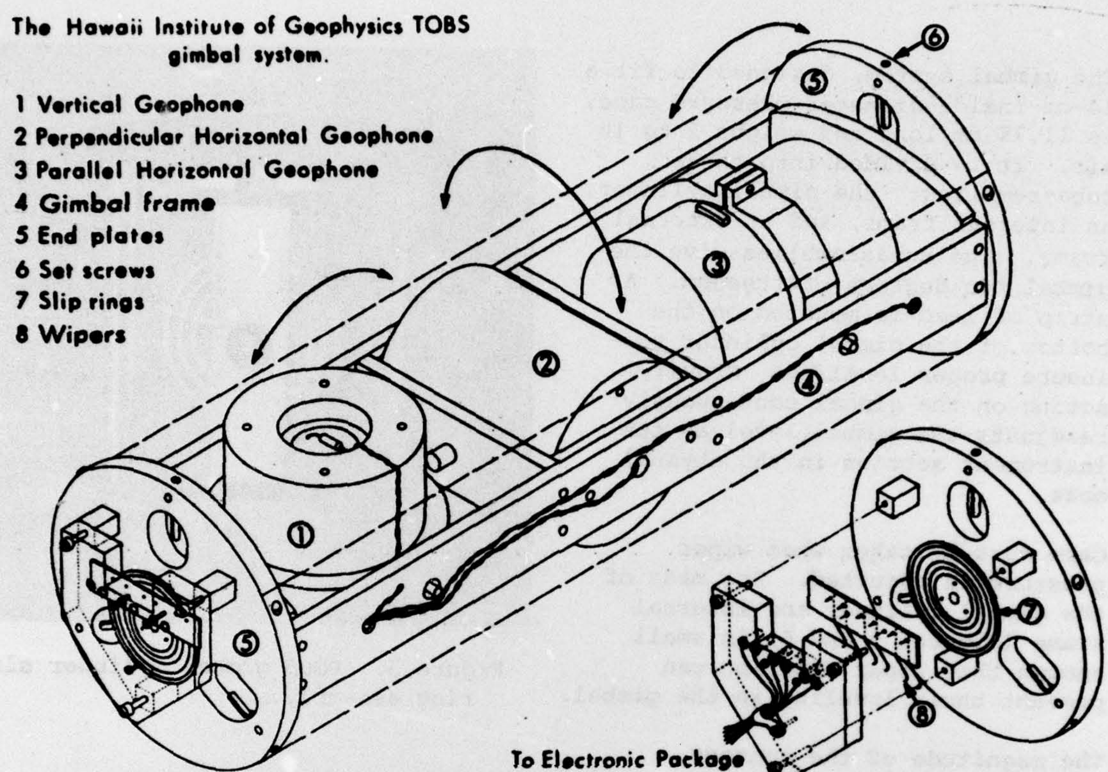

Figure 7. TOBS gimbal assembly drawing.

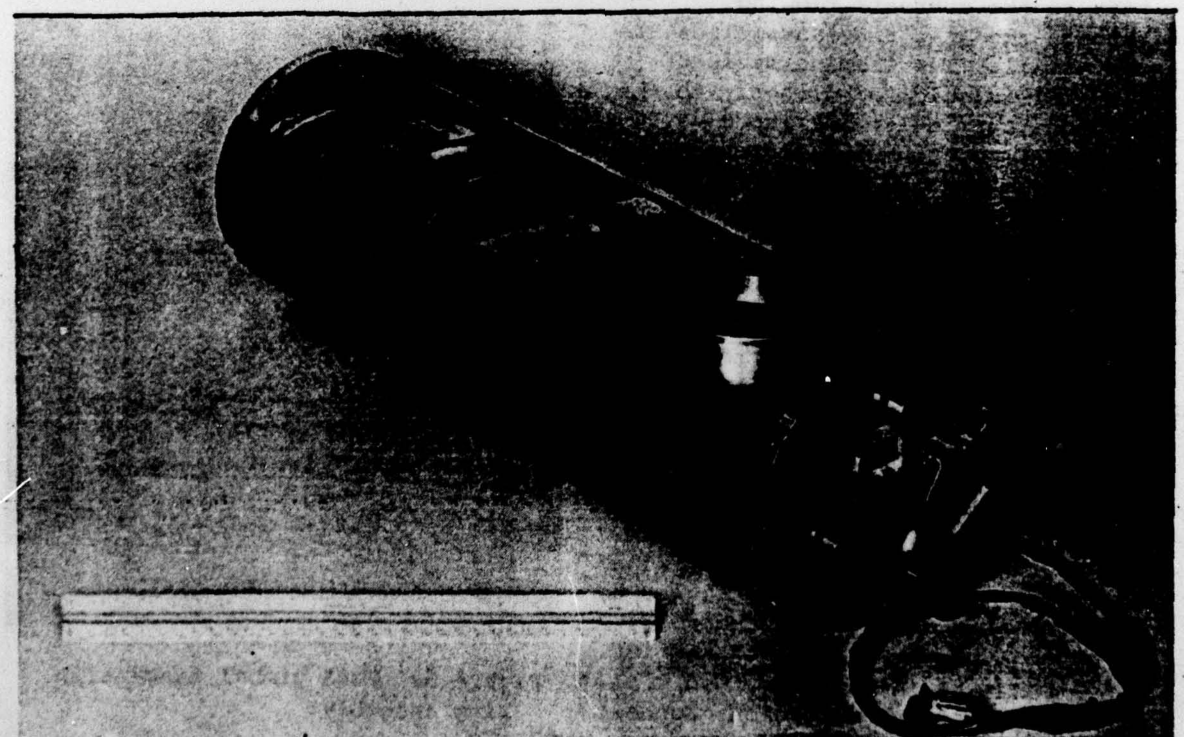

Figure 8. TOBS gimbal system.

so that all are self-leveling. The gimbal system is locked into the pressure case with six set screws. The slip rings are mounted to the gimbal frame in the same fashion as on the POBS gimbals, but the brush assemblies are different (Figure 9).

The HS-10, 2-Hz, 210-kΩ geophones are modified by Geospace Corp., by removing the threaded bottom stud. Critical damping is provided by a 750-kΩ resistor connected directly to the geophone terminals in parallel with the 750-kΩ input resistance of the amplifier and calibration circuits.

Field Experiences

Approximately 40 gimbal systems have been built during the past 5 years. They have been shown to be reliable, relatively maintenance-free, and rugged. As a standard part of our routine prelaunch checkout procedure, all slip ring assemblies are tested. We find that we have to readjust the brushes, retrim the gimbal, or clean the slip rings 3 to 5 percent of the time.

The only mechanical damage the gimbal system sustained was during an air freight shipment. The POBS was being shipped in its pressure case, and apparently it was dropped far enough to deform the lead ballast strip so that it locked the gimbal. This problem was solved by placing a screw in the middle of the lead strip. We are currently considering using the air carriers as a testing technique to insure the mechanical ruggedness and reliability of our instruments.

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Figure 9. TOBS gimbal slip ring assembly.

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